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THE YAHARA RIVER IMPROVEMENT

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THE YAHARA RIVER³ IMPROVEMENT

By

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and

JOHN HENRY NEEF ✓

A Thesis Submitted for the Degree of
BACHELOR OF SCIENCE
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L I S T O F D R A W I N G S .

PLATE I . Cross-Sections of River.

PLATES II and III. Profiles of Railroad Tracks.

PLATE IV . Design for Street Concrete Arch Bridge.

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THE YAHARA RIVER IMPROVEMENT

The Yahara or Catfish river is that stream which rises not far from Waunakee, flows southeast into 4th lake, thence from 4th lake to 3rd lake, from 3rd to 2nd lake, from 2nd into 1st lake, from 1st lake on through the city of Stoughton and into the Rock river near Edgerton, a few miles below Lake Koshkonong. The river is not navigable on account of several rapids and shallow places.

The Report of the United States Chief Engineer for January, 1840, contains a report by Thos. J. Cram, Capt. Topographical Engineer. He makes a report of a survey with a view to the improvement of the navigation of Rock river, from the Illinois line as far up the same as the contemplated point of the intersection with the Milwaukee and Rock river canal, and, also, of the haven of said river next below Lake Koshkonong, to Madison. The general scheme was this: to dig a canal south from Lake Winnebago to the Rock river, also another canal west from Milwaukee to the Rock river. This river was to be deepened, thus opening up navigation through to the Mississippi, in order to avoid the rapids of the Wisconsin and Fox (or Needah) rivers' route. Capt. Cram relates some interesting facts in his report of the "Survey of the Rock river Haven." The four lakes, 4th, 3rd, 2nd, and 1st, together with the Catfish river, consti-





View from Island, looking down stream.



View of Site for Proposed Lock.

tute the said Haven. He describes Fourth lake as the summit lake, with a periphery of about 20 miles and with an area of between 15 and 16 square miles, the longest diameter as 6 miles and the diameter at right angles to this as 4 miles.

He derived some interesting information from Governor Dodge, who said that a canal having Fourth lake as its summit reservoir might easily be constructed from this lake northwest to the Wisconsin river, as in times of high water the Indians were said to have made the passage through from the Wisconsin river to Fourth lake in their canoes. Capt. Cram reports the channel between Fourth and Third lakes as about one mile in length, varying in width from 60 to 100 feet; immediately at the Fourth lake outlet it is but 35 feet wide. The lake was shallow here with a shoal running out for 1000 feet or more. The current of the stream was proportionately strong; the depth not exceeding 2 feet. The total fall in this mile of channel was approximately estimated as 22 inches. The method to improve this channel was to deepen it and clear out sunken timber and brush, and to construct a lock of suitable lift at the entrance of the stream into Third lake; in a manner, however, not to produce stagnant water in the channel above.

He reports Third lake as between 12 and 13 miles in circumference, and covering about 6 square miles. Its largest diameter is 3-1/2 miles with a greatest width at right

angles to this of 3-1/2 miles, and having a depth along the usual boat track of more than 10 feet. . The channel into which this lake discharges has a depth of 9 feet immediately at its outlet, with a muddy and sandy bottom, but the depth soon decreases to 4 feet, and finally down to 2 feet, where the bottom becomes gravelly, with numerous sandstone and limestone rocks projecting above the surface, with water only about 12 inches deep surrounding them. After leaving this bed of rocks, the channel carries from 3 to 6 feet of water to the entrance of Second lake. The length of the channel between Third and Second lakes is 7/10 of a mile, and its breadth averages not less than 350 feet, and its current is quite gentle.

Second lake has a periphery of about 10 miles, with a surface area of 4-1/2 square miles. Its greatest length is 3-1/2 miles and greatest width at right angles to this is about 1-1/2 miles. The water has a depth of over 9 feet on the regular boat track. The length of the channel between Second and First lakes is 3-1/2 miles long. At the outlet of Second lake there are many rocks that can be removed without blasting. At a short distance below the outlet a rapid occurs with a fall of about 1 foot in 300 feet, when there is a depth of only 13 inches; below this the depth increases to 3 feet and the bottom is sandy. About a mile lower down a second rapids occurs and for 560 feet the depth is slightly less than 2 feet, after which the depth increases to 3 and 4 feet. A little further down the river broadens to a width

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of $1/4$ mile with a depth of 4 to 6 feet. After this a third rapid occurs in which the depth is only 12 inches; several large rocks appear above the surface where an old Indian fish dam crosses the stream. Below this the river has an average depth of 2 feet. The method that appears to be suitable for the improvement of the channel (between Second and First lakes), is to erect a dam at the foot of the third rapids to produce slack water between it and Second lake to cover the intervening obstructions, and to deepen the channel between the foot of said rapids to First lake so as to give sufficient depth over the bar into this lake.

First lake has a periphery of about 10 miles and has about 5 square miles of area. The greatest length is $3-1/3$ miles and the greatest width at right angles to this is about 2 miles. Along the boat track the water varies from 7 to 10 feet in depth, except near the outlet where the depth over the bar is but 2 feet. The distance from First lake to Dunkirk is about 9 miles. The average breadth of the stream is about 130 feet, occasionally reduced to 60 feet at short bends. The depth varies from $2-1/2$ to 5 feet. The fall is so uniform, and the current so gentle, no dams are necessary. The channel would have to be dredged in a few places, also a few of the elbows cut through.

From the head of Dunkirk falls to the Rock river is $12-1/3$ miles. There is a continued succession of short rapids with intervening pools. There is a fall of 34.7 feet

in a distance of 5.6 miles. The improvement of navigation of that part of Catfish which is below the head of Dunkirk falls may be effected by constructing four dams, that may not exceed 10 feet in height each, and the construction of as many locks; and by deepening the channel when it may be needed from the foot of the last rapids to the Rock river.

The distance from Fourth lake to the Rock river is 40-1/2 miles. Since an ample supply can be drawn from the natural reservoir at all times, the proper depth of the channel can always be controlled. The total cost and estimate could not be obtained unless a more accurate and extensive survey is made.

Although the above report of Capt. Cram's concerns more than the present contemplated improvement of the Yahara river, it tends to show how easily navigation may be instituted between the four lakes and down the river as far as Dunkirk, about 3 miles below Stoughton.

As this thesis especially applies to that part of the Yahara river between lakes Mendota and Monona, the remainder of it will be concerning this portion of the river.

On the first plat of Madison, which was made in 1836, the principal streets were platted as they now are. On this plat where Hancock street now is, was shown a canal with a street on either side, and a space of several acres reserved at the Monona lake end for mill purposes. Mr. John V. Suydam of Green Bay, made the survey and plat. He evidently

took no levels nor made a personal inspection along the route of his proposed canal, as the deepest cut through Hancock street would be somewhere near 50 feet. Nevertheless in his report he says: "The place for the canal is perfectly practicable and the fall sufficient for mills and other machinery." For a number of years there were two streets close together shown on the Madison plats where Hancock street now is, and were called East and West Canal streets. These were afterwards changed into one street and called Hancock street.

On March 23, 1846, the trustees of the village of Madison published proposals to lease the hydraulic power within the corporation limits of the village, the substance of which is as follows: It had been ascertained that the difference in elevation between Third and Fourth lakes, if it were sufficiently improved, would create a water power of considerable magnitude, and since the legislature of the territory of Wisconsin did, by an act approved Feb. 3, 1846, grant the corporation of Madison the right to lease, improve or otherwise dispose of said water power. Public notice was given that the trustees would receive proposals for leasing the right of the water power for a term of years on condition that the lessee excavate a canal 40 feet wide on the bottom, and 50 feet wide at the top, from Fourth to Third lake, and to erect a flouring mill; all to be performed within a reasonable length of time. Bonds were to be given for

the faithful performance of the work. The trustees had had levels taken and their engineer reported a difference of 3.71 feet between the two lakes. They said that this difference could be increased to 5-1/2 or 6 feet by damming up the Fourth lake outlet. In reply to this, a proposition was made by Simeon Mills to lease the water power for 60 years, which proposition was accepted. Subsequently Mr. Mills had a careful survey made of the level of the lakes, and not being satisfied with the results, abandoned the undertaking.

In 1847, L. J. Farwell, afterward Governor Farwell, came to Madison. Forseeing its natural advantages as a business center and capital of the state, he made an extensive purchase of real estate, which included the unimproved water power between lakes Mendota and Monona. During the following winter he commenced the improvement of the water power of the Yahara. The fall between the two lakes as taken by a number of engineers, varied from 3' - 10" to 4' - 11". This variation was no doubt due to the changing levels of the two lakes, as the levels were taken at different seasons of the year. The building of a dam at the outlet of lake Mendota was facilitated by the natural dam built by the ice ramparts, of which the present Willow walk in Tenney Park, is a part. This rampart was caused by the expanding ice of the lake shoving up material from the shallow lake bottom into a ridge. During the spring of 1849, Mr. Farwell took advantage of this natural ridge and here built

a dam across the outlet of lake Mendota, thereby raising the water of the lake 2 feet. The Yahara, being very circuitous and its channel obstructed by logs and brushwood, was straightened, cleaned out, and deepened from one lake to the other. The level of lake Monona was lowered almost a foot by removing obstructions at its outlet. This would make a total head of nearly 6 feet, which, according to the present levels of the two lakes, does not seem possible, unless the dam at lake Mendota was considerably higher than it now is.

During the summer of 1849 a long building was erected at the outlet of lake Mendota, with a saw mill in one end and a grist mill in the other with two runs of stone. The next year Mr. Farwell increased his grist and flour mill so that he had eight runs of stone instead of two. The mill was put in full operation in the fall of 1850.

In 1836 a Mr. Briggs built a woolen mill, which was an extension of Farwell's mill, and it was also run by the water power furnished by the Yahara. It contained the best machinery of those times, employed about 20 hands and turned out 125 yards of woolen goods per day. It was thought that even then that only about one-half of the total power was used. The grist and flour mill was successfully operated for a number of years until it was burned down March, 19, 1895. The water power has not been used since the burning of the mill, and was bought up by the city in order to control the level of lake Mendota.





Williamson Street Bridge, Looking up Stream.



View of Completed Lock, Looking up Stream.

All improvements on the Yahara since the burning of the old grist mill has been made by the Madison Park and Pleasure Drive Association. The citizens of and the visitors to Madison, have a great deal for which to thank this Association. The first improvement of the Yahara by the Association was made by changing what was known as Willow Park into Tenney Park. This Park is on the southwestern bank of the Yahara and extends southeast along the river as far as Johnson street and has a frontage on lake Mendota of 460 feet and comprises about 14 acres. It is beautifully laid out, having been done according to plans of Mr. O. C. Simonds, a competent landscape gardner.

The first mention of the present contemplated improvement of the Yahara river was given in a paper delivered by Professor John M. Olin before the Association at their Annual Meeting and Banquet held Tuesday, April 15, 1902. In this paper Professor Olin laid briefly the general scheme for beautifying and improving the river. He showed how a strip of the unimproved land on each side of the river might be obtained and improved, the bridges raised, the river cleaned and deepened, the excavated material used for filling purposes, and a lock constructed at the old mill dam, thus permätting pleasure boats and launches to go from on e lake to the other.

On January 9, 1903, there met at the home of Senator William F. Vilas, by invitation, some thirty citizens of

Madison, for the purpose of exchanging views as to the proposed Yahara improvement. After the subject had been discussed fully, a motion was adopted, with but one dissenting vote, favoring the improvement. On January 25th, at a meeting of the directors, a motion was unanimously adopted, favoring the proposed improvement, upon certain conditions named, one being that not less than \$15,000 be raised for use during the coming season, and that certain land along the river be acquired for park purposes by donation. At this meeting a committee was appointed to secure land and also a committee to confer with the presidents of the railway companies as to the elevation of their tracks. On January 29th, the latter committee met by appointment at Chicago the officials of the Chicago & Northwestern and the Chicago, Milwaukee, & St. Paul railway companies, who assured the committee that these companies would heartily cooperate with the citizens of Madison in the proposed improvement. This committee, at this meeting, submitted to the railway officials a copy of the bill that it was proposed to have introduced in the legislature requiring the city of Madison and the railway companies to elevate all bridges spanning the river, so as to give not less than 8 feet clearance between the water, at its ordinary stage, and the bottom of the bridges, with a clear span of 30 feet.

On February 6, the resolution adopted by the direc-

tors on January 25th was laid before a special meeting of the common council, as well as a copy of the proposed bill. After the matter was fully explained to the council, resolutions were adopted favoring the improvement and the passage of the proposed bill. The bill was introduced into the Senate and its passage was secured. This law, by its terms, would not go into effect until there should be filed in the office of the Secretary of State, a certificate, signed by the Governor, certifying that there had been filed in the office a statement, under oath, by the president of the Association, showing to the satisfaction of the Governor that there had been subscribed a sum of not less than \$15,000 for the proposed improvement. On April 14th, 1903, a statement was filed in the Governor's office under oath that not only the sum of \$15,000, but the sum of \$20,614 had been subscribed for the proposed improvement. The railway companies did not wait for the filing of this affidavit but started to make preparations for the raising of their bridges before April 1st.

There were made many liberal donations of land along the river. On the northeast side of the river commencing at Sherman avenue, the Hausmann Brewing Company made the first donation of a strip of 133 feet in width, and extending along the river bank as far as the right of way of the Chicago & Northwestern railroad. The city owns the land from the railway right of way to Washington avenue and a

resolution was adopted by the common council donating a strip 133 feet wide. A strip of 50 feet wide between Washington avenue and Main street was donated by Mr. Cooley. From Main street on to Monona lake a strip 50 feet wide was secured, except one short block and one lot, the owners of which would not come to terms. Thus the Association has secured a strip along the northeasterly side of the river except one short block and one lot.

On the southwesterly shore of the river the Association already owns Tenney Park, which extends as far as Johnson street. Along the bank of the river from Johnson street to Williamson street, the city now owns Water street which might be widened by purchasing a narrow strip of land from the adjoining property owners. From Williamson street to Lake Monona on the southwesterly side of the river a strip of land has been secured, also a strip 40 feet wide from the Fauerbach Brewing Company and a strip 50 feet wide from Mr. George Soelch.

It will be seen from the above that either the city or the Association in trust for the city, will, upon the completion of this improvement, have the ownership and control of practically all the shore on either side of the river between the two lakes. This will be of great value both to the city and to the owners of the adjoining property. It will secure for the public free and uninterrupted use and enjoyment of this river and its banks, and will protect property owners against the construction or maintenance of

anything offensive.

After the river has been dredged, the bridges raised, the lock built and put in operation, roads and walks built along the banks, shrubs and trees set out, and the banks sodded and completed, the city of Madison will have a beautiful, interesting, and useful park, of which its citizens and visitors may well be proud. This improvement will not only increase the value of the property in the immediate vicinity, but will also increase the value of property all over the city, by making Madison a more desirable and valuable spot. It will tend to promote more excursions from the surrounding cities, it will help convert Madison into a summer resort; it will show to visitors the public spirit of Madison's citizens. This will aid the growth of the city and will induce visitors of a desirable kind to become permanent residents.

Not only the immediate property owners, not only the citizens of Madison, but the students and visitors to this city have a great deal for which to thank the Madison Park and Pleasure Drive Association for the improvement of the Yahara river.

THE PROPOSED IMPROVEMENT.

The field work consisted of determining the difference in elevation of lake Mendota and lake Monona; measuring the length of the Yahara river; taking cross-sections at each hundred foot station; running profile lines on the four tracks crossing the river, also Sherman avenue and Williamson street; taking Hydrography notes, in the bay at entrance to Yahara river, and determining the elevations of all bridges, top of rails or center of roadway and bottom chords.

From elevations obtained by running levels between the two lakes it was found that the slope of the river was quite irregular, as would be expected since the water along the upper part of the channel spreads over considerable marsh land to the East, and is backed up by vegetable growth. The difference in elevation between the two lakes was 3.9 feet, making the slope of the river between Sherman avenue bridge and Williamson street bridge 0.84 feet. At ordinary stages of water in the lakes, the vertical distance through which a boat would have to be raised, to gain entrance to lake Mendota, or lowered to get from lake Mendota to the river, would be about 2.25 feet

With station 0+0 located about 100 feet north of Sherman avenue bridge, stakes were set along the bank every

100 feet as far as Williamson street bridge. The location of all bridges, with respect to Sherman avenue bridge, and their respective lengths, are given below:

	STATION	LENGTH
BRIDGE #1 Sherman avenue bridge	1 + 0	73 ft.
BRIDGE #2 Chi. & N. W. R. R. (main line)	21 + 63	76 "
BRIDGE #3 Chi. M. & St. P. R. R. (Portage branch)	22 + 55	95 "
BRIDGE #4 Washington avenue	26 + 63	50 "
BRIDGE #5 Main street	30 + 87	60 "
BRIDGE #6 Chi. & N.W. R. R. (Milwaukee div.)	33 + 70	80 "
BRIDGE #7 Chi. M. & St. P. R. R. (Watertown div.)	38 + 85	120 "
BRIDGE #8 Williamson street	39 + 40	78 "

It will be seen from the above that eight bridges, four highway, and four railroad bridges, cross the Yahara river.

From Sherman avenue bridge, Station #1 to Williamson street bridge, Station #39 + 40, a careful estimate of the cost of dredging was made, while from Williamson street bridge to lake Monona a rough estimate of cost was made. The total length of the Yahara is about 1 mile (5280 ft.), of which approximately 4000 feet, or $\frac{4}{5}$ of a mile, is in-

cluded, carefully estimated in this thesis. Inasmuch as the 4000 feet under consideration includes all of the bridges, railroad and highway, which cross the Yahara, it will be seen that the cost of dredging the portion from Williamson street bridge to lake Monona would represent but a small per cent of the total expenditure.

At each 100 foot station set along the bank, cross-sections of the river were obtained by taking soundings at intervals of 5 feet, and results plotted as shown on PLATE I.

Profile lines were run on railroad tracks, readings taken every 50 feet, for 2000 feet each side of center of the bridge, except the Chi. & N. W. R. R. bridge (main line), which was taken 3000 feet on each side. PLATES II, & III.

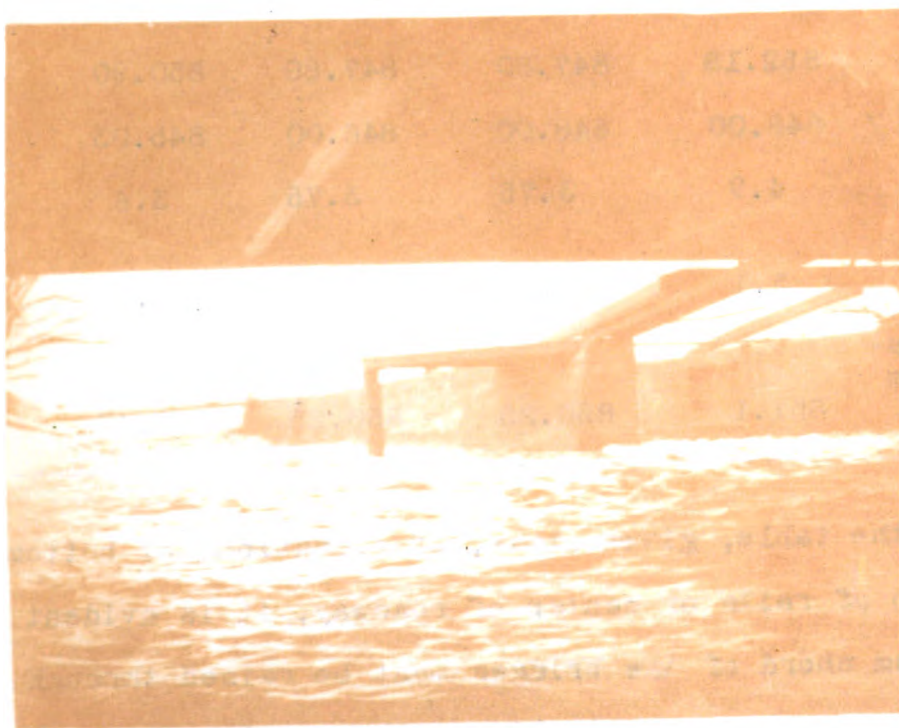
Readings, sufficient to determine and plot 1 foot contours were taken in the bay of Mendota, from which flows the Yahara and from these readings the amount and cost of dredging was estimated and the contours in PLATE IV plotted.

The elevations of the bottom chord and top of rail on railroad bridges, and the elevation of center of roadway and bottom chord of highway bridges were determined in order to get new elevations of the same with a clearance of 8 feet from mean water level.

	C. & N.W. Main line	C.M. & St. P. Portage Branch	C. & N.W. Milw.Div.	C.M. & St. P.Water- town Div.
Elevations of top of rail or cen- ter of road- way.	849.40	849.40	849.90	852.05
Bottom chord	944.77	847.21	846.40	849.91
Clearance	2.4	4.8	3.9	7.7
Height to be raised	5.6	3.2	4.1	0.3
Required eleva- tion of bottom chord	850.57	850.41	850.50	850.21

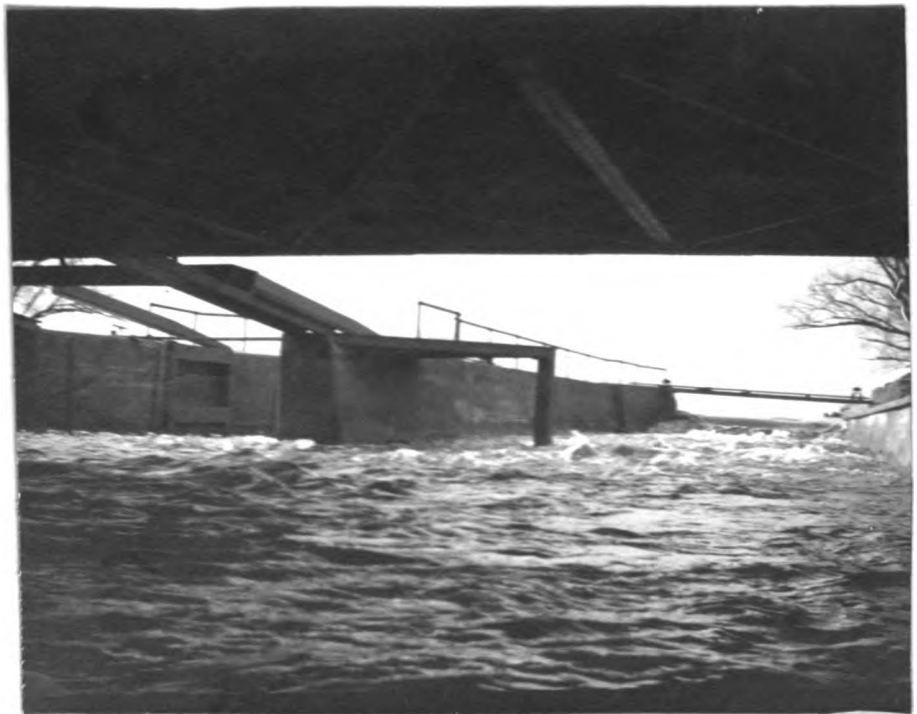
	Sherman Avenue	Main Street	Washing- ton Ave.	William- son St.
Elevations of top of rail or cen- ter of road- way.	852.18	847.80	847.80	850.90
Bottom chord	848.00	848.00	846.00	845.03
Clearance	4.9	3.75	3.75	3.6
Height to be raised	3.1	4.25	4.25	4.4
Required eleva- tion of bottom chord	851.1	850.25	850.25	849.43

From the table, given above, of elevations of bottom chords and top of rails or center of roadway, it is evident that the bottom chord of the bridges must be raised through a vertical distance as shown in line marked "Height to be





View of Completed Lock, Looking up Stream.



View of Lock, as Seen from the Shore near Sherman Avenue Bridge, Looking up Stream.

raised." The Chicago & Northwestern (main line) track would have to be raised 5.6 feet, requiring a fill of 5.6 feet at each end of the bridge; the Milwaukee division track, of the same Company, would have to be raised 4.6 feet, requiring 4.6 feet fill at each end of the bridge. The Chicago, Milwaukee and St. Paul (Portage branch) track would have to be raised 3.3 feet requiring 3.3 feet fill at each end of bridge, while on the Watertown division track of the same Company, there would have to be a raise of but 0.3 of a foot, requiring 0.3 of a foot fill at each end of the bridge. The proposed grades and profiles of these tracks are shown on PLATES II and III.

The Sherman avenue bridge, of the through plate girder type, would require a raise of 3.1 feet, making the fill 3.1 feet at each end of the bridge. This amount of fill can be reduced to 2.1 feet by lowering the floor system 1 foot. Doing this would lower the otherwise necessary street grade at the bridge 1 foot, and an amount about equal to the cost of lowering the floor system would be saved by making the fill 1 foot less than otherwise necessary, with the advantage of having a more uniform grade along the avenue.

It was thought best to replace the old bridges at Main street and Washington avenue with steel concrete beam-bridges of sufficient strength to carry the heaviest road roller. The work of designing these bridges will not be given in detail, but the estimate of the cost is shown in the

city's share of the cost of improvement.

The Williamson street bridge, of the Pratt Truss form, can not economically be made to give the required 3 feet clearance, in addition to which, being but 30 feet wide and containing one street-car track, does not allow a vehicle and car on the bridge at the same time.

As a substitute for this bridge, an elliptical steel concrete arch was designed, with the following dimensions: span 50 feet, rise 7.5 feet; clearance for 16 feet each side of center to be not less than 8 feet; width of bridge 58 feet; sidewalks 5 feet and roadway 44 feet. The depth of arch ring at springing line - 5 feet; depth at crown 1.5 feet. The ribs are composed of two steel bars, each $2\frac{5}{8}$ inch x $\frac{3}{4}$ inch placed 2 inches from intrados and extrados and spaced 2 feet center to center as shown on PLATE IV. Where splices are to be made, $\frac{3}{4}$ inch rivets are to be used, which leaves $1\frac{13}{32}$ square inches or 0.01 of a square foot, net section of bar to resist tension. Steel rods 4 inches by $\frac{3}{4}$ inches are placed at both ends of each rib.

This arch, PLATE IV, was designed according to the theory of William Cain by which the divisions along the neutral line are such that the length of the neutral line, divided by $I_1 + n I_2$ will be constant for each division. I_1 = moment of inertia of concrete; I_2 = moment of inertia of steel, both about the neutral axis, and n = modulus of elas-

ticity of steel divided by the modulus of elasticity of concrete, or 20 in this case. Instead of taking concentrated loads on the arch, a uniform live load of 140 pounds per square foot of arch was used, this being sufficient, or equivalent to any loads liable to come on the arch.

LOCK AT MENDOTA LAKE OUTLET

At the outlet of lake Mendota there is to be constructed a lock. There is a small island in the river at this outlet which facilitates the construction. A temporary dam may be built on the lock side of the island allowing all the water to flow through the channel on the other side and not interfering with the construction of the lock. At the outlet, and in connection with this lock the city is to build retaining walls along the banks and two suitable dams on either side of the island, to control the level of lake Mendota.

The design for the lock is shown on PLATES V, & VI. The inside width of the lock, is 12 feet in the clear and will accomodate a boat 60 feet in length. The height of the top of the lock is 2.3 feet above lake Mendota high water mark. At low water mark in the river, the lock will accomodate a boat drawing 3 feet of water. In order for a boat to pass through, it will require the handling of 25,000 gallons of water, twice. For instance: in locking a boat through from lake Mendota, the lock will first be filled, which will require letting into the lock about 25,000 gallons from the lake. This will require between two and three minutes, by the use of the valves in the upper gates. The upper gates are then closed and the valves in the lower gates,

opened. It will then require from two to three minutes, for the water to be discharged from the lock into the river. The lower gates are then opened and the boat passes out into the river, the whole operation taking from eight to ten minutes.

The bed of the river, underneath the lock, is firm gravel mixed with sand and no piles will be required for the foundations. The foundation and walls are to be Portland cement broken stone concrete in the proportion of 1.3:5. The inside of the lock is vertical while the outside has a batter of three inches to the foot. The walls are thicker at the gates to withstand the thrust due to the pressure of the water against the gates.

Both upper and lower gates are the usual miter canal gates, turning upon a vertical axis. The weight of the gates is counterbalanced by having the turning lever weighted, thus enabling them to be turned by hand. The only forces to be overcome in turning is the resistance of the water and the friction at the bottom of the vertical axis. The valves for filling and refilling the lock are located in the gates and are operated by a small lever at the top of the gate, within easy reach from the side of the lock.

In order to go from one side to the other a small foot bridge, raised high enough for the bottom to have the necessary clearance, may be suspended on brackets from the

side of the Sherman avenue bridge, which is close to the down stream end of the lock.

On the northeasterly side, at both the upper and lower gates, will be two platforms built of plank and supported by posts in the stream for use in operating the lever arms of the gates.

The estimated cost of the lock is as follows:-

710 cu. yds. earth excavation at .75 per cu. yd.	\$425
485 " " Portland cement concrete at \$8. per cu. yd.	3880
2160 ft. B.M. flooring at \$40 per M.	90
2408 ft. B. M. floor timber at \$25. per M.	60
3080 ft. B. M. sheet piling and bracing at \$25 per M.	80
580 ft. B.M. concrete forms at \$25 per M.	150
580 ft. B. M. temporary dam at \$25 per M.	15
Rock and manure filling for dam	15
Pumping and bailing	150
Lower gates, valves and iron work for same	200
Upper " " " " " " "	175
Foot bridge	25
	\$5265
10% for engineering and incidentals	525
Total	\$5790

COST TO THE CITY.

Two steel concrete beam bridges for Main street and Washington avenue, span 50 feet, together with abutments, - - - - -	\$5000.
1800 cu. yds. fill on above streets at .25 per cu.yd.	450.
Cost of raising bridges and lowering floor system of Sherman avenue bridge - - - - -	75.
250 cu.yds. fill at .25 per cu. yd. - - - - -	65.
	<u>\$5590.</u>

STEEL CONCRETE ARCH FOR WILLIAMSON STREET.

614 cu.yds. concrete at \$7.50 per cu. yd. - - - -	4595.
345 sq.yds. macadam at .60 per sq. yd. --- - - - -	207.
21 cu. yds. concrete at \$8.50 per cu. yd. - - - -	18.
2300 lbs. steel bars at .04 per lb. - - - - -	92.
124 feet railing at \$3.25 per lineal foot - - - -	400.
550 cu. yds. fill at .20 per cu. yd. - - - - -	110.
Relaying and repairing 530 sq. yds. of macadam at .30 per sq. yd. - - - - -	368.
	<u>\$5790.</u>

Estimated cost of retaining walls near lock.

206 cu. yds. concrete at \$8. per cu. yd. - - - -	2450.
Main street and Washington avenue bridges (above)	5590.
	<u>\$13830.</u>
10% engineering and incidentals - - - - -	1383
Total cost to city - - - - -	<u>\$15213.</u>

COST TO CHICAGO AND NORTHWESTERN RAILROAD COMPANY.

Double Track.

16940 cu. yds. fill at .30 per cu. yd.	\$5082.
6040 cu. yds. ballast at .40 per cu. yd.	2416.
56.8 cu. yds. masonry at \$10. per cu. yd.	568.
Estimated cost of raising bridge	<u>100.</u>
	8166.
10% engineering and incidentals	<u>816.</u>
	\$8982.

Milwaukee Division.

3660 cu. yds. fill at .30 per cu. yd.	\$1098.
1510 cu. yds. ballast at .40 per cu. yd.	604.
42 cu. yds. masonry at \$10 per cu. yd.	420.
Estimated cost of raising bridge	100.
35 cu. yds. retaining walls at \$4. per cu. yd.	<u>140.</u>
	\$2360.
10% engineering and incidentals	<u>236.</u>
Milwaukee Division	2596.
Main line	8982.
Estimated cost of raising track and system on interlocking	<u>200.</u>
Total cost to C. & N. W. R. R. Company	\$11778..

COST TO CHICAGO, MILWAUKEE & ST. PAUL RAILROAD COMPANY.

Portage branch.

3550 cu. yds. fill at .30 per cu. yd.	\$1064.
1380 cu. yds. ballast at .40 per cu. yd.	552.
Plate girder	3800.
102 cu. yds. concrete at \$7.50 per cu. yd.	764.
	<u>\$6180.</u>
10% engineering and incidentals	618.
	<u>\$6798.</u>

Watertown division.

Plate girder	\$4000.
Abutments, 102 cu. yds. concrete at \$7.50 per cu.yd.	764.
400 cu. yds. fill at .30 per cu. yd.	120.
220 cu. yds. ballast at .40 per cu. yd.	88.
	<u>\$4972.</u>
10% engineering and incidentals	497.
Watertown division	<u>\$5469.</u>
Portage branch	6798.
Cost of raising interlocking system at C. & N.W.	
crossing,	<u>50.</u>
Total cost to C. M. & St. P. Co.	12317.

The total expense to this Company is seen to be greater than that to the C. & N.W. R.R. Co. which fact is due to the necessity of replacing old bridges by new plate girders, which would require additional expenditure on concrete abutments.

Only a part of the total expenditure should be considered in the improvement as it is work which would have to be done some time in the future.

MADISON PARK AND PLEASURE DRIVE.

Cost to Association.

18100 cu. yds. dredging between Sherman avenue and

Williamson street bridges at .18 per cu. yd. \$3258.

450 cu. yds. dredging in lake Mendota at .20 90.

6000 cu. yds. dredging from Williamson street to

lake Monona at .18 1080.

Cost of lock complete

5265.
\$9603.

10% engineering and incidentals

960.

Total cost to Madison Park and Pleasure Drive Assn. \$10563.

Total estimate of cost for improvement.

Cost to city. - - - - - \$15225.

C. & N. W. R. R. Co. - - - - - 11780.

C. M. & St. P. R. R. Co. - - - - - 12320.

Madison Park and Pleasure Drive Association - - 10563.

Grand total - - - - - \$49888.





The River, Looking Down Stream from Sherman
Ave. Bridge after Dredging.

S P E C I F I C A T I O N S

Work Contemplated and General Methods of Operations.

The contractor is to make the necessary excavations, preparations for, and the construction of foundations, abutments, retaining walls, arches, spandral walls, filling, etc.; the removal, cleaning, and storing of old span; do all pumping, bailing and draining; all sheathing, bracing and supporting; all lighting and watching; clear away all rubbish, excavated material, sheathing, bracing, etc.; and furnish all materials, tools, implements and labor to complete the work.

These specifications are intended to secure the execution of the work in the most sound, workmanlike and substantial manner, and all materials used in construction shall be new unless otherwise noted, and the best of their respective kinds.

The plans furnished by the city comprise the following:

Sheet #1, General plan and profile of steel concrete arch.

Sheet #2, Detail plans of steel concrete arch.

Such plans are submitted by the bidder and approved by the council.

The engineer shall furnish such further detail plans as in his judgment the execution of the work demands.

Loads and conditions.

The dead loads assumed in determining the dimensions are as follows:

Concrete - 140 lbs. per cu. ft.

Earth filling - 120 lbs. per cu. ft.

Macadam - 8" deep, 140 lbs. per cu. ft.

The live load assumed in determining the dimensions - 140 lbs. per sq. ft. for width of arch.

Conditions of calculation.

Modulus of elasticity of concrete = 1,500,000 lbs.

" " " " steel = 30,000,000 "

Maximum compression allowed on concrete.

Including stress due to 40 degrees variation in temperature, 600 lbs. per sq. in.

Maximum tension allowed on concrete.

Including stresses due to 40 degrees variation in temperature, 75 lbs. per sq. in.

Maximum shear allowed on concrete.

75 lbs. per sq. in.

Maximum stress allowed on steel.

The steel ribs under a stress not exceeding 18000 lbs. per sq. in. must be capable of taking the entire bending moment of the arch without aid from the concrete and have areas of not less than one hundred and fiftieth part of the total area of arch at crown. The actual stress when

imbedded in and acting in combination with concrete shall not exceed 20 times the allowed stress on concrete.

Old structure.

The old truss shall have its members suitably marked to correspond with plan furnished by the Engineer. The spans shall then be carefully removed and compactly and satisfactorily stored at such a point in Madison as the engineer shall designate. Before storing, all parts that show signs of rust, shall be thoroughly cleaned and given one coat of paint, to be furnished by the city.

Street car rails, their supports, including stringers and planks between rails, are property of the railway company and will be removed by them after proper notice from the engineer. All other plank, joists, masonry, etc. shall become the property of the contractor and shall be removed by him.

Excavating.

The contractor shall make all the excavations necessary in such manner and to such depths and widths as will give ample room for building the structures they are to contain, and for bracing, supporting, pumping, draining and removing from such excavations all materials that the engineer may not deem proper for foundations.

All materials encountered shall be removed until a firm, secure foundation is reached.

All excavated material, except wood, shall be deposited back of the abutments where directed by the engineer.

The contractor shall furnish sufficient pumping plant, and provide drainage satisfactory to the engineer. Water shall not be allowed to rise on any concrete until the mortar has set to the satisfaction of the engineer.

Cement.

The cement to be used shall be true Portland cement. Acceptance of any cement to be used shall rest with the engineer, and shall be based on the requirements given below.

Fineness.

The fineness of the Portland cement shall be such that 99% shall pass through a sieve of 50 meshes per lineal inch, and at least 90% shall pass through a sieve of 100 meshes per lineal inch. The fineness of natural cement shall be such that at least 90% shall pass through a sieve of 50 meshes per lineal inch.

Initial set.

Cement mixed neat with from 25 to 30% of water to a stiff paste, made into cakes on glass, and as soon as prepared placed in moist air, shall be appreciably indented, if a natural cement at the end of 10 minutes, if a Portland cement at the end of 30 minutes, by the end of a wire 1/12 of an inch in diameter, loaded to a total weight of 1/4 pound.

Soundness.

Cement mixed as above on glass plates shall not crack scale or warp if placed in moist air until set, and in water

for the remainder of 24 hours and then further subjected to boiling water; steam and water for 24 hours.

Tensile strength.

Tensile tests of cements shall be made as provided by American Society of Civil Engineers. Natural cements shall be placed in moist air one hour, and Portland cements 24 hours, and afterwards immersed in water until tested. That portion of the sand to be used on the work retained on a sieve of 30 meshes per lineal inch, and passing through a sieve of 20 meshes per lineal inch, shall be used in making tests. Briquettes in tension shall give the following results:

Natural cement.

Neat. 1 day, 65 lbs.; 7 days, 100 lbs.; 28 days, 125 lbs. 1 cement 2 sand, 7 days, 50 lbs.; 28 days, 90 lbs.

Portland cement.

Neat. 1 day, 130 lbs.; 7 days, 400 lbs.; 28 days, 500 lbs. 1 cement, 3 sand, 7 days, 150 lbs.; 28 days, 225 lbs.

Sand and broken stone.

The sand shall be composed of clean, sharp, sand, which will pass a sieve having holes $\frac{1}{4}$ of an inch square, and not less than 50% of which will be retained on what is known as a No. 30 sieve.

The broken stone used shall be composed of clean, hard sound stone, free from gravel stone cemented together, and

shall be washed clean when the engineer may consider it necessary. Tests of sand and broken stone will be made whenever the engineer may consider it necessary, and the contractor shall furnish the necessary apparatus and assistance for making the same.

For Grade 1 concrete, the largest particle shall not exceed 1-1/2 inch in largest dimensions, with the same proportion of fine crushed stone specified above. For Grades 2 and 3 concrete, no particle shall be greater than 2 inches in its longest dimensions, and the smallest of which shall be retained upon a sieve with holes 1/4 inch square. The size of the particles shall be so proportioned that those passing a sieve with 3/4 inch mesh will fill the voids of the portion retained by the same, without more than 10% excess.

Concrete.

The grades of concrete to be used are as follows:

Grade 1. For arches, girders and abutments - one part Portland cement, two parts sand, and four parts broken stone.

Grade 2. For foundations, spandrel walls and facing of abutments, one part Portland cement, 3-1/2 parts sand, and 7 parts broken stone.

Grade 3. For lower portion of abutments, 1 part natural cement, 2-1/2 parts sand and 4 parts broken stone.

Mixing.

The concrete may be mixed either by hand, with shovels, or by concrete mixing machines. If machines are used, they shall be of an approved kind, for which the proportion of each batch shall be accurately measured. Consideration will not be given to any continuous mixer in which the proportions depend on shovelers. No more water shall be used than the concrete will bear without quaking when rammed.

If the mixing is done by hand, suitable level platforms shall be provided on which the sand and cement shall be well mixed before water is added. Water shall be added by spraying or by bucket as the engineer may decide. The cement, sand and water shall then be thoroughly mixed until a mortar is produced which is of such consistency as to fall into a mass when dropped from a shovel held above the mortar board. To the mortar thus prepared shall be added the broken stone thoroughly wet and the whole mass turned over with shovels not less than four times and until each particle of stone is completely covered with mortar.

Depositing.

The mixing must be done as rapidly as possible, transported from mixing platform to the work, deposited and rammed into place immediately after mixing. Concrete not rammed into place before setting shall not be retempered, but rejected entirely from the work. The contractor shall not be allowed to deposit concrete in water, or drop it into place from an elevation exceeding 6 feet.

The concrete shall be spread in layers not exceeding 6 inches in thickness, and thoroughly rammed with rammers to the satisfaction of the engineer. The operation of ramming shall be so conducted as to form a compact, dense, impervious artificial stone. The ramming must be so thorough as to perfectly compact the concrete, and to fill the voids so that the mortar comes to the surface, and that the concrete shall show a perfectly smooth face when forms are removed.

All exposed surface finished and unfinished work shall be kept constantly moist by sprinkling with water at short intervals. The contractor shall not permit walking over or on the concrete until it has set for a sufficient length of time, to be determined by the engineer.

In joining new concrete to other concrete that has already set, precaution shall be taken to secure a perfect bonding by sweeping and washing the work already in place and by spreading over its surface a thin layer of mortar before the concrete is added. All joints between new and old concrete shall be subject to the approval of the Engineer.

The top of walks, etc. shall be finished with a 1 inch coat of facing mortar, using a coarse sand and rammed into a thorough bond with the base. The surface shall be finished as far as possible with a straight edge, lightly troweled, and the gloss removed with a wet brush as directed.

Expansion joints shall be made in sprandrel walls, cornices, and parapets of each arch at the springing lines,

or joints $1/6$ span from the spring lines and at such other points, if any, as shown by plans. The expansion joints shall be filled with a bituminous mixture satisfactory to the engineer.

After completion of the arches and spandrels, and before any fill is put in place, the top surface of the arches and abutments, and lower 6 inches of the inner surface of spandrel walls shall be coated with a heavy coat of semi-liquid mortar, one part Portland cement, one-half part slacked lime and three parts fine sand, spread to leave a smooth finish. After this is set hard, it shall be given a heavy coat of pure cement grout.

All filling with sand, earth, cinders, or other material satisfactory to the engineer shall be made to the elevation shown on plan. The same shall be thoroughly compacted by ramming in 6 inch layers. The fill over any arch shall not be put in until at least two weeks after arched concrete has been completed.

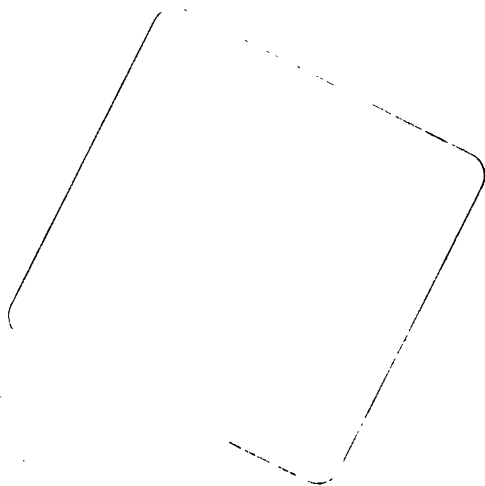
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Professor of Railway
Engineering.



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